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## *TAMARIX HOHENACKERI* BUNGE, A NEW RECORD FOR THE FLORA OF MEXICO

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### ABSTRACT

*Tamarix hohenackeri* Bunge is reported here for the first time for the flora of Mexico. It also represents the first record for the American continent. This species, native from Asia, was collected along riversides of the river San Salvador (Ensenada, Baja California). A detailed morphological description of the newly reported taxon is provided, and the taxonomic treatment of *T. hohenackeri* is also discussed. As a result of this study, the presence of six species of the genus *Tamarix* is confirmed for Mexico, and a dichotomous key for the *Tamarix* species in Mexico is presented.

Key words: invasive flora, Mexico, Tamaricaceae, *Tamarix*, taxonomy.

### RESUMEN

Se documenta por primera vez la presencia de *Tamarix hohenackeri* Bunge para la flora de México. Se trata, a su vez, de la primera cita para el continente americano. Esta especie, nativa de Asia, ha sido recolectada en los márgenes del río San Salvador (Ensenada, Baja California). Se aporta una descripción morfológica detallada del nuevo taxon citado y se discute, también, su estatus taxonómico. Como resultado del estudio, se indica la presencia de seis especies del género *Tamarix* y además se aporta una clave para la identificación de los representantes de *Tamarix* en México.

Palabras clave: flora invasora, México, Tamaricaceae, *Tamarix*, taxonomía.

## INTRODUCTION

*Tamarix* (Tamaricaceae) is mainly found in Asia, where two main centres of speciation and diversification have been reported (Baum, 1978). The first one would correspond to the Indo-Turanian area, where the oldest species, such as *Tamarix ericoides* Rottl., are mainly located. The second centre is basically placed around the Middle East, extending to the Eastern Mediterranean and Turkey. From both geographical areas, the genus migrated in a southerly and westerly direction towards Africa and Europe, and also in a northerly and easterly direction towards the cold deserts and the Pacific coast of Asia (Baum, 1978).

Most of the vegetative and reproductive morphological characters widely used for the taxonomical identification of the *Tamarix* taxa are rather variable among populations and even within a single individual. This heterogeneity has led to the recognition of a large number of taxa, increasing the taxonomic complexity of this genus. In fact, about 200 taxa have been described since Linnaeus (1753). There is no general consensus on the number of species or on their taxonomic treatment, and consequently between 54 and 90 species are currently recognized (Baum, 1978; Yang and Gaskin, 2007).

The genus *Tamarix* includes trees or shrubs 2-10 m high, branched and mainly glabrous, with a deep root system. Branches are green, reddish brown, dark brown or black. Leaves are alternate, sessile, scale-like, entire, sometimes decurrent, from slightly auriculate to amplexicaul or even vaginate, glabrous, mostly with salt-secreting glands. The inflorescences are racemose, simple or compound, often paniculately branched; and growing on branches of the previous or current year. Flowers are small, tetra or pentamerous and white to pink or purple. Bracts are entire, 1-8 mm length, from sessile to amplexicaul. Sepals vary from triangular-lanceolate to widely ovate; and their lobes are entire or slightly denticulate to dentate. Petals are deciduous or sometimes persistent after anthesis; ovate, elliptic or obovate, and sometimes with an unguiculate or cuneate base. The stamens are 4-15, with filaments inserted on the nectariferous disc. The ovary is mostly conic and with 3-4 styles. Numerous seeds are characterized by an apical sessile hairy pappus.

From an ecological point of view, *Tamarix* species are phreatophytes, which form dense groves growing in ravines, river banks and also in saline soils, mostly located in arid and semi-arid zones. The species have a remarkably high growth rate, reaching their habitual height in a short period of time (Velasco, 2008). Their salt and drought tolerance plus their fast growth, combined with very attractive blooms, have played a key role for the ornamental use of certain *Tamarix* species. Thus,

they have also been cultivated to reduce desertification, as wind curtains, or also to stabilize soil in sand dunes (Melgarejo, 2000; Gaskin and Schaal, 2003; Natale et al., 2008).

By the 19th century, some *Tamarix* species were introduced to America and Oceania (Baum, 1967; Di Tomaso, 1998; Stromberg, 1998; Csurhes, 2008; Natale et al., 2008). In the United States, *Tamarix* species have been available in ornamental plant catalogues from the first half of the 19th century, and plant nurseries early offered shipment from the Atlantic coast to any state (Prince and Sons, 1837; Warner Harper, 1903). Since then, some *Tamarix* species have spread to North America and these plants are currently considered as the second worst plant invasion in the United States (Gaskin and Schaal, 2003). As a consequence, much effort has been expended to eradicate the *Tamarix* populations in the United States through national programmes (Anonymous, 2005). Both chemical and mechanical methods have been widely used (Sisneros, 1990), recently complemented by biological control programs (Milbrath et al., 2003).

The taxonomic and morphological complexity of this genus makes the correct identification of the invasive species remarkably difficult. In America, the morphological differentiation among closely similar species, such as *Tamarix ramosissima* Ledeb. and *Tamarix chinensis* Lour., has become notably problematic, due to their resemblance and also because of the frequent presence of hybrid forms, not previously reported in their native areas (Baum, 1967; Gaskin and Schaal, 2003; Gaskin and Kazmer, 2009).

In Mexico, *Tamarix* species were introduced through the United States and also due to commercial plantations (Glenn and Nagler, 2005). However, there are scarce publications focused on the genus *Tamarix* in Mexico. For the time being, five different species have been reported: *Tamarix ramosissima* Ledeb. (*Tamarix pentandra* Pall.), *Tamarix chinensis* Lour., *Tamarix parviflora* DC., *Tamarix gallica* L. and *Tamarix aphylla* (L.) Karst. (Villaseñor et al., 2002; Chambers and Hawkins, 2004; Rebman, 2007). *T. ramosissima* and *T. chinensis* are widely distributed in the western United States, with populations in all of the bordering states with Mexico. In the Mexican territory, these species are abundant in the Lower Colorado, Sonora and Chihuahua deserts, reaching Guaymas (Sonora) and the southern part of the Baja California peninsula (Zamora-Arroyo et al., 2001; Chambers and Hawkins, 2004; Glenn and Nagler, 2005; Rebman, 2007). In the case of *Tamarix parviflora*, it has been reported from California of the United States (Gaskin and Schaal, 2003), and some Mexican locations of Baja California and Baja California Sur (Anonymous, 2011). Populations of *T. gallica* have been mainly stated along the United

States coast of the Gulf of Mexico (Gaskin and Schaal, 2003). There are some records of *T. gallica* for Mexico (Villaseñor et al., 2002), whose reference vouchers could not be reviewed for this study. Finally, *T. aphylla* shows a similar distribution to those of *T. ramosissima* and *T. chinensis* (Glenn and Nagler, 2005). Nevertheless, the distribution of this species in Mexico may be larger since other populations have been also identified in Baja California (pers. obs.) and in other southern locations such as “El Tule”, near Oaxaca.

Field investigations and herbarium revisions carried out in Mexico identified samples that do not correspond to any of the formerly mentioned *Tamarix* taxa. Hence, a new record for the Mexican flora is given here.

## MATERIALS AND METHODS

Plant material was collected in Baja California during the spring of 2010, and it is conserved at the herbarium ABH (University of Alicante, Spain). For the species identification and morphological characterization, different monographs of the genus *Tamarix* were consulted (Baum, 1978; Zohary, 1987; Yang and Gaskin, 2007). In addition, herbarium vouchers from BCMEX, G, K, MA, MO, PRC, PR, VAL and W (Thiers, 2011) were also examined. The abbreviations of author names follow those proposed by Brummitt and Powell (1992), amended by the IPNI (2012). Plant images were taken using Pentax K200D reflex digital camera with Pentax D FA Macro 100mm F2.8 WR.

## RESULTS AND DISCUSSION

The species *Tamarix hohenackeri* is reported from Mexico for the first time, on the basis of plant material collected beside the San Salvador river (Ensenada, Baja California) (Fig. 1, Annex). This *Tamarix* population grows along both sides of the river, forming a long belt. Besides, herbaria reference works allowed us to find a voucher from Colorado (United States) in the Missouri herbarium (MO04808092), which also corresponds to *T. hohenackeri* (Annex). Therefore, this voucher, originally identified as *T. parviflora*, may represent the first record of the species for the American continent.

The following description of *Tamarix hohenackeri* is based on the observations of the herbarium material observed.



Fig. 1. Image of a specimen of *T. hohenackeri* from Mexico. A. general view of the herbarium voucher (ABH57398); B. detail of inflorescence; 1. apical bracts; 2. fasciculate racemes; 3. basal bracts.

*Tamarix hohenackeri* Bunge, Tentamen, p. 44 (1852).

Tree, up to 5 m tall, entirely glabrous. Leaves ovate-triangular to lanceolate, acute, with a decurrent narrow base, sometimes slightly auriculate, 1.5-3.0 mm long. Inflorescences composed mostly of fasciculate arranged racemes, placed in spike-like panicles (not branched). Racemes 3.0-8.0(11.0) cm long, (5.0)5.5-6.0 mm wide, on short peduncles (3.0-10.0 mm long), naked or with a few bracts; rachis glabrous. Bracts of the racemes 1.5-3.0 mm long; lowermost bracts oblong and obtuse, wider and shorter than the narrowly triangular and acute uppermost bracts; bract length sub-equaling pedicel length at the lower part of the racemes to sub-equaling or slightly exceeding calyx length at the apex of the inflorescences. Pedicels 0.5-1.75(3.0) mm long, usually longer in the lower part of the racemes, occasionally with 1-3 small secondary bracts. Sepals 5 (rarely 4), ovate, usually acute, with narrow hyaline margin, 1.0-1.3(1.5) mm long, 0.6-0.8 mm wide. Petals 5, white or yellowish to pink, persistent, ovate-oblong to oblong, or widely elliptic, slightly emarginated, sometimes slightly keeled, 1.8-2.75 mm long, 1.0-2.0 mm wide. Stamens 5 (rarely 6), inserted between the lobes of the nectariferous disc; additional filaments inserted on the lobes. Anthers mostly not apiculate. Ovary always with 3 styles. Fruit 3-4 mm long.

The taxonomic placement of *T. hohenackeri* is not totally resolved, because this species was considered by Baum (1978) as a synonym of *T. smyrnensis* Bunge. This taxonomical treatment is especially relevant, since his monograph is a world-wide reference for the genus *Tamarix*. However, both taxa were originally described as two independent species (Bunge, 1852). Other authors as Yang and Gaskin (2007) and certain Asian botanists (e.g. N. Lachashvili, in sched. (W2008-21042); Belolipov and Haydarov, in sched. (MO6047301)) have also recognized *T. hohenackeri* as a species independent from *T. smyrnensis*. According to our data, there are enough morphological differences supporting the idea that the synonymization of *T. hohenackeri* into *T. smyrnensis* might not be fully appropriate. These morphological differences have not been only based on bibliographical data (Bunge, 1852; Yang and Gaskin, 2007), but also on the detailed study of herbarium vouchers of *T. hohenackeri* and *T. smyrnensis*, including the type material of both species (see Annex). The main vegetative and reproductive morphological differences between *T. hohenackeri* and *T. smyrnensis* are shown in Table 1. The most useful character to discriminate among these species corresponds to the fasciculate placement of racemes and their size, although the size and shape of bracts, sepals and petals are also essential for their accurate identification.

Table 1. Morphological comparison between *T. hohenackeri* and *T. smyrnensis*.

|                                    | <i>T. hohenackeri</i> Bunge   | <i>T. smyrnensis</i> Bunge   |
|------------------------------------|---|--|
| Raceme disposition                 | in spike-shaped panicles, solitary or fasciculate. Racemes pedunculate and laxly flowered                               | in panicles compound at their base. Racemes sessile and densely flowered   |
| Raceme length (mm)                 | 30.0-80.0   | 8.5-25.0   |
| Bract shape                        | short oblong (at lower part of racemes) to narrowly triangular (at upper part of racemes)                               | narrow triangular-lanceolate, acute  |
| Bract length (mm)                  | 1.5-3.0   | 1.0-2.0(3.0)   |
| Bract-flower ratio                 | equaling pedicel (at lower part of racemes), almost equaling or slightly exceeding calyx (at the upper part of racemes) | almost equaling or slightly exceeding calyx (at lower part of the racemes)   |
| Pedicel length (mm)                | 0.5-1.75(3.0)   | subsessile ( $\leq 0.5$ )  |
| Sepal length (mm)                  | 1.0-1.3(1.5)  | 0.7-1.0  |
| Sepal shape                        | ovate, acute, with hyaline margin   | ovate-lanceolate, acute, with hyaline margin   |
| Petal size:<br>length x width (mm) | 1.8-2.75 x 1.0-2.0  | 1.2-1.9 x 1.2-1.6  |
| Petal shape                        | ovate-oblong to oblong, sometimes elliptic, slightly emarginated. Sometimes slightly keeled                             | suborbicular-elliptic, variable from slightly ovate to slightly obovate, with the lower half clearly carinate-gibose |

The native distribution area of *Tamarix hohenackeri* extends, at least, from the eastern Black Sea to Mongolia, central Asia and south-western Asia (Yang and Gaskin, 2007). There it is in contact with two closely related species, *T. ramosissima* and *T. austromongolica* Nakai. It is highly probable that *T. hohenackeri* was introduced in North America by the 19th or early 20th century for ornamental purposes, but was confused or intermixed with other similar ornamental species such as *T. ramosissima*. The distribution area of *T. hohenackeri* in North America could be wider than expected, since some additional vouchers of *T. hohenackeri* from the United States and Mexico could be misidentified as other species, such as *T. chinensis*, *T. ramosissima* and even *T. parviflora*.

With this new record, and including the previously available data (Zamora-Arroyo et al., 2001; Villaseñor et al., 2002; Glenn and Nagler, 2005), six *Tamarix* species are part of the aloctonous flora of Mexico: *Tamarix aphylla*, *T. gallica*, *T.*

*parviflora*, *T. hohenackeri*, *T. ramosissima* and *T. chinensis*, as well as the hybrids between the two latter species. Among them, *T. aphylla*, *T. hohenackeri*, *T. ramosissima* and *T. chinensis* were newly collected during the fieldwork conducted in April 2010, from different locations of Baja California (see Annex).

Below, a dichotomous key is presented for the six species of *Tamarix* reported for Mexico. The main morphological features are focused on leaf shape and insertion, raceme length and its disposition, bract shape, relative bract length, number, shape and size of the perianth sections and the site of insertion of the staminal filaments on the nectariferous disc.

#### Dichotomous key for the identification of *Tamarix* species in Mexico

- 1 Leaves vaginate ..... *T. aphylla*
- 1 Leaves sessile with a narrow base, sometimes slightly auriculate at their lower half but never vaginate ..... 2
- 2 Flowers tetramerous ..... *T. parviflora*
- 2 Flowers pentamerous ..... 3
- 3 Staminal filaments arising from the apex of the nectariferous disc lobes .....  
..... *T. gallica*
- 3 Staminal filaments arising between the nectariferous disc lobes ..... 4
- 4 Inflorescences with both solitary and fasciculate racemes (groups from 2 to 4) ..... *T. hohenackeri*
- 4 Inflorescences with racemes always solitary ..... 5
- 5 Racemes 5-7 mm wide. Bracts equal or slightly longer than the pedicel. Pedicels as long as sepals, at least the lowermost pedicels of the raceme ..... *T. chinensis*
- 5 Racemes 3-5 mm wide. Bracts equal or slightly longer than the calyx. Pedicel length always shorter than that of the sepals ... *T. ramosissima*

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## ANNEX

### Selected material:

- T. aphylla***. MEXICO. Baja California: Mexicali, Laguna Salada, junto a carr. Tecate - Mexicali, 11SPS177042 (32°34'8,4" N-115°44'46,1" W), 0 m, 18-4-2010, Leg. J.L. Villar, M.A. Alonso, A. Juan (ABH55929); Oaxaca: El Tule, 14QQP5286 (17°2'53,7" N-96°38'1,6" W), 1560 m, 20-4-2010, Leg. A. Juan (ABH56707); Sonora: Región del Pinacate, rancho entre dunas cercanas a la estación de ferrocarril Gustavo Sotelo, 16-9-1980. Leg. M. Equihua, J. López-Portillo, E. Ezcurra, Det. R.S. Felger (BCMEX005453).
- T. chinensis***. MEXICO. Baja California: Ensenada, carr. Ensenada - Maniadero, 11RNR350143 (31°45'49,2" N-116°37'49,4" W), 100 m, 15-4-2010, Leg. J.L. Villar, M.A. Alonso (ABH57396); Ensenada, carr. Ensenada - Maniadero, 11RNR350143 (31°45'49,2" N-116°37'49,4" W), 100 m, 15-4-2010, Leg. J.L. Villar, M.A. Alonso (ABH57397); Ensenada, Estero Beach, carr. Ensenada - La Bufadora, 11RNR355088 (31°42'50,5" N-116°37'31,2" W), 0 m, 15-4-2010, Leg. J.L. Villar, M.A. Alonso (ABH57461); La Angostura, 11RNQ6475 (31°24'28,3" N-116°19'36,2" W), 172 m, 24-4-2010, Leg. J.L. Villar, M.A. Alonso (ABH55928).
- T. hohenackeri***. ARMENIA. Syunik province, SSE Sisian, Between Darbas and Ltsen, 14-6-2007, Leg. M. Oganessian, Ter-Voskanyan, E. Vitek, Det. J.L. Villar (W2010-02963). REPUBLIC OF GEORGIA. Ad rivulos pr. Helenendorf, 1838, Hohenacker (W1889-880289, W0227453, PRC452707, 452708, G-Boiss, isoelectotypes); Prope pag. Karajazy, 21-5-1908, Leg. Koenig (W1940-22731, W1954-4398); Lagodechi Reserve, 41°44'25" N 45°13'35" E, 15-6-1995, Leg. J. Gaskin (MO5568882, *ut T. smyrnensis*); East Georgia, Iori Table land, Vashlovani reserve, 25-5-2002, Leg. K. Ishagashvili, N. Lachashvili (W2009-06712, *ut T. smyrnensis*); East Georgia, Dedoplistskaro district, Iori plateau, Lekistskali gorge, ca. 41°12'36" N, 46°32'31" E, 14-3-2006, Leg. Nikoloz Lachashvili (W2008-21042). IRAN. South 7 km west of Dahst along Qez-qaleh valley, 18-5-1995, Leg. H. Akhani (W1999-07675, *ut T. ramosissima*). MEXICO. Baja California: Ensenada, Maniadero, Río San Salvador, 11R587235243, 803 m. 16-4-2010, Leg. J.L. Villar, M.A. Alonso, A. Juan (ABH57398). UNITED STATES OF AMERICA. Colorado: Mesa County, along frontage road to Interstate 70, at exit to DeBeque, 39°19'24" N, 108°12'00" W, 4919 ft, 2-6-2005, Leg. Robert M. King, Robert M. Garvey (MO04808092, *ut T. parviflora*). UZBEKISTAN: Tashkent, Bekabaddistrict, 40°31.82' N-69°5.00' E, Leg. Igor Belolipov, Hislat Haydarov (MO6047301).
- T. ramosissima***. MEXICO: Baja California: Playas de San Felipe, 11RQQ010508 (31°10'26,4" N-114°53'27,3" W), 0 m, 16-4-2010, Leg. J.L. Villar, M.A. Alonso (ABH57459); Mexicali, Laguna Salada, junto a carr. Tecate - Mexicali, 11SPS177042 (32°34'8,4" N-115°44'46,1" W), 0 m, 18-4-2010, Leg. J.L. Villar, M.A. Alonso, A. Juan (ABH57462); Isla Ángel de la Guarda, East side of island, in middle of narrow dry arroyo, 29°27'579" N-113°24'830" W, 85 feet, 3-2006, Leg. P. García (BCMEX0013719); Mexicali, Lower Rio Colorado valley, 32°13'48.4" N-115°02'55.8" W, 10 m, 17-3-2006, Leg. Richard S. Felger, K. Reichhard, E. Soto-Montoya (BCMEX013156); Ensenada, Ctra Ensenada - San Felipe, 31°10' N-115°19' W, 21-7-1980, Leg. A. Díaz (BCMEX0010101, *ut T. pentandra*); La

Annex. Continuation.

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- Bocana, 31°33' N-116°10' W, 30-9-1982, Leg. Ortiz, Arroyo, Mora (BCMEX005512, *ut T. pentandra*); Ensenada, Arroyo, zona adentrada a la presa, 31°53' N-116°35' W, 15-6-1980, Leg. Gálvez, López, Héctor, Det. Gálvez (BCMEX000166, *ut T. pentandra*); Ensenada, Agua Viva, carr. Ojos Negros, 31°54' N-116°26' W, 3-7-1981, Leg. V.M. Preciado (BCMEX000119, *ut T. pentandra*); Ensenada, 31°53' N-116°40' W, 21-7-1980, Leg. L. Heredia (BCMEX000037, *ut T. pentandra*); Isla Cedros, Casa de Piedra del Gran Cañón, 28°10' N-115°15' W, 50 m, 27-12-1986, Leg. Hugo Cota (BCMEX003223, *ut T. pentandra*); South of Santa Catarina, near coast south of Punta Canoas and Puerto Mujeres, Cañon Lázaro, 29°24'69" N-115°02'22" W, 20-150 m, 17-4-1997, Leg. J. Rebman, J. Merzbacher, T. Deméré (BCMEX009904); Along the Ensenada to Tecate highway, about 28.5 miles north of Ensenada, near Predio Belen, North of Guadalupe, along cold water stream, 32°11' N-116°29' W, 500 m, Leg. R.F. Thorne, W. Wisura, W. Steinmetz (BCMEX001393); Sonora: Hermosillo, La Victoria, 29°06'49.219" N-110°52'17.786" W, 310 m, 25-5-1996, Leg. R. Palafox, Det. O.J. Soto (BCMEX003545, *ut T. pentandra*).
- T. smyrnensis.** CYPRUS. Cap Arnaouk, près polis, Leg. M. Haradjian (MO1621122); Ad alveos prope litora maris in viciniis Kuklia Amathus et aliis locis, 5-1862, Leg. Kotschy (W, G-Boiss). GREECE. Rhodes. Bords des torrents près Salakos, 31-5-1870, Leg. Bourgeau (W1889-150434, G-Boiss); Ad ripas Penes prope Larissam, 2-8-1882, Leg. Heldreich (G); Etolias-Akaranias, Mesolongui, coast by the salt works, c. 5 km NW of Mesolongi, clayey marsh, 9-6-1997, Leg. Nielsen (G). TURKEY. In arenosis humidis Smyrnae, april-majo 1827, Leg. Fleischer (W1889-320298, PRC452718, PRC452719, PRC452720 isotypes); Smyrne, Leg. Monbret (W1889-223513); Marais d'eau saumatre situés entre la Papeterie et la mer, près de Smyrne, 1854, Leg. Balansa (MO5475118, W1889-81992, W1889-80859); C4 Icel. 12 km S Mut, 200 m, 6-6-1966, Leg. F. Sorger (W1990-07003); Pamukkale E C2 Denizli, 400 m, 28-6-1967, Leg. F. Sorger (W1990-06983); Gök Pinar. B6 Sivas, 1600 m, 9-9-1977, Leg. F. Sorger (W1990-06992); 4 km S Uluabat, Damm A2 Bursa, 27-6-1977, Leg. F. Sorger (W1990-06989).
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